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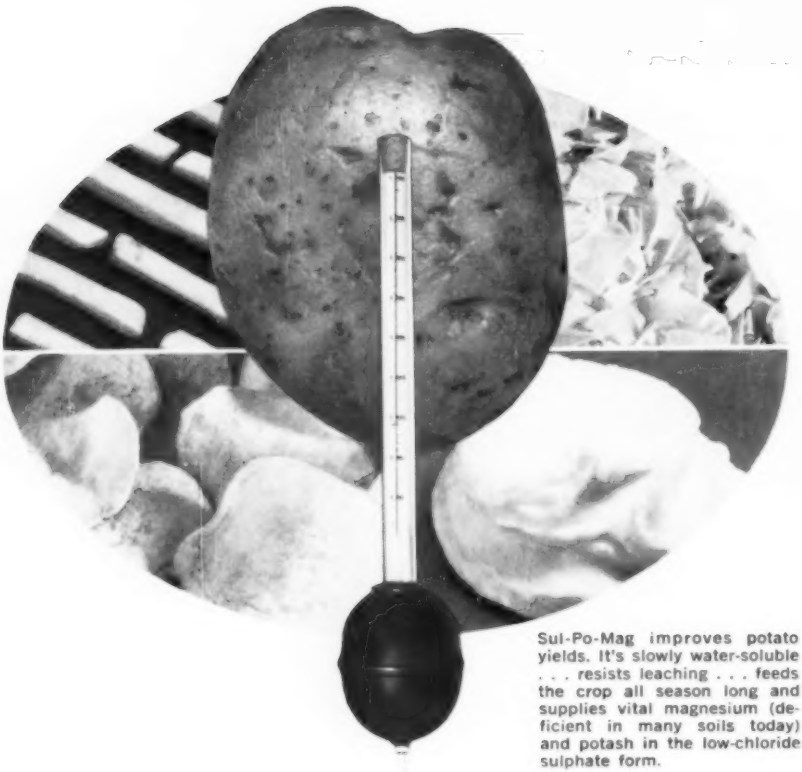

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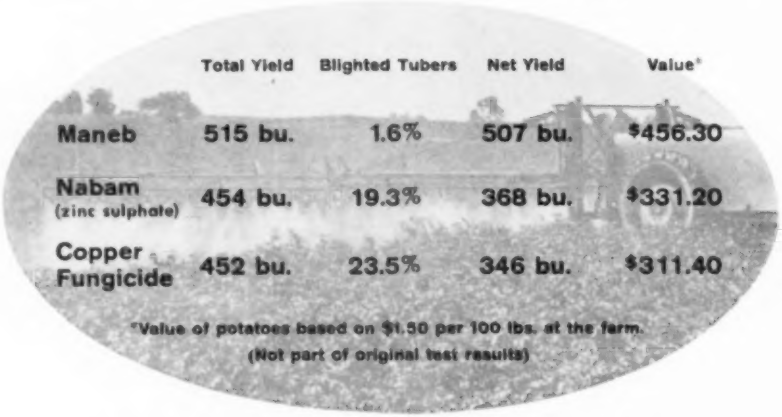

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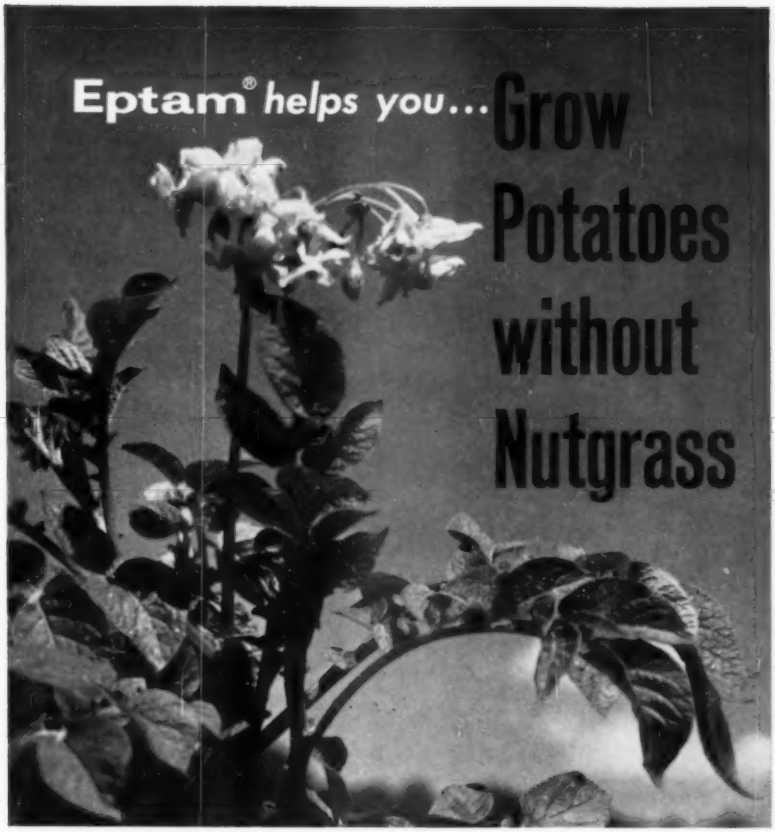

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CHIP COLOR IN RELATION TO POTATO STORAGE[1]

FREDERICK J. STEVENSON AND CHARLES E. CUNNINGHAM[2]

Red Dot Foods, Inc. grows, on its farms at Rhinelander and Waupaca, Wisconsin and near Mobile, Alabama, about 40% of the potatoes required for its many chip factories. The other 60% is purchased from various sections of the country, some as far away as California. The rapidly rising transportation charges, the damage that often occurs to potatoes in transit, and the high cost of new potatoes in the early spring are incentives for the company to grow and store a larger percentage of its yearly needs. In preparation for such a development, two large modern storehouses were built recently, one in Rhinelander, and the other at Waupaca; to augment the storage capacity that was already in use.

The effects of storage temperatures and the rapidity of reconditioning after removal from storage on chip color, are given major emphasis in the potato research program.

MATERIALS AND METHODS

From 20 to 25 thousand new seedlings, representing many crosses and a number of selfed lines are grown annually on the Research Farm at Rhinelander. About 10% of these are selected at harvest time. The criteria used in making the selections are: tuber shape, depth of eyes and potential yield. The second year these selections are grown in 10-hill rows. About 25% of these are selected again and samples of each placed in 50° F. and 42° F. storage. After periods varying from 9 to 18 weeks, the samples are removed from storage. Those from 50° storage are chipped upon removal, those from 42° are cured 4 weeks in 70° to 80° temperature and chipped.

At Rhinelander, in succeeding years, the best of the selections from the standpoint of the appearance of the crop produced, and the color of their chips after storage are grown in replicated yield trials, and, or in larger plots for increase. Relatively large numbers are sent to Alabama where the advanced seedling varieties are grown in replicated yield tests and the newer ones in 5-hill rows for observation.

In the replicated yield tests, standard varieties and new varieties or promising seedlings from the various potato breeding programs in the United States and Canada are compared.

Two harvests of the more advanced seedlings are made, usually about a month apart. Samples from the early harvested varieties grown at Rhinelander and from both harvests in Alabama are sent to the laboratory in Madison and chipped on arrival. The remainder from the late harvested plots are again placed in storage at 50° and 42° F. A number of the most promising seedlings that are being increased for commercial production are stored at 50°, 42° and 38°. The samples from 50° are cooked on removal from storage, those from 42° and 38° are reconditioned at a temperature varying from 70° to 80°. One sample of each variety

[1]Accepted for publication September 19, 1960.

[2]Director of Research and assistant Plant Geneticist, Red Dot Foods Inc., Madison, Wis.

is cooked on removal from these storages at weekly intervals from 4 to 7 weeks to determine the rapidity of the reconditioning ability of each.

All chips are fried at a laboratory in the chip plant at Madison. The oil in which the chips are fried is maintained, as nearly as possible, at a temperature of 350° F. The chips are cooked until bubbling stops. The color of the chips is judged by comparison with a standard set of chips showing a range of colors (Fig. 1).

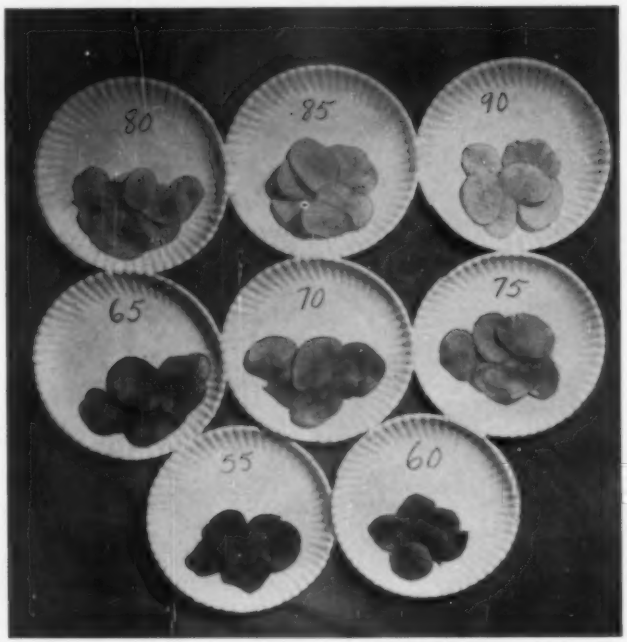

FIG. 1.—Standard set of chips, showing a range of colors, with which all colors of chips are compared. Chips with a rating of 80 or higher are commercially acceptable.

RESULTS

Chip color on arrival from field — Samples of most of the varieties grown at Rhinelander and Waupaca and all those grown in Alabama are chipped on arrival at the chip factories, direct from the harvest fields. All potential commercial varieties and seedlings are tested for those conditions.

The data for chip color of potatoes grown at Rhinelander during the four growing seasons 1956-1959 inclusive and chipped before cold storage are given in Table 1. It will be noted that, with one exception, 100% of the varieties in the 1958 and 1959 tests produced chips with good to excellent color. The exception is found in the data for the 1959 yield test harvested September 17. Only 58% of the varieties in that test produced chips with an index of 80 or higher. A heavy freeze on the night preceding the harvesting operations probably accounted for the dark colored chips produced from some of the varieties. On the day

TABLE 1.—*Chip color of potatoes grown at Rhinelander, Wisconsin and cooked at Madison before cold storage — 1956, 1957, 1958, 1959.*

Year tested	Kind of test	Dates[1] Plant	Harvest	Chip	Varieties tested No.	Chip color index[2] Range	Mean	Varieties with index 80 or higher No.	Pct.
1956	Yield	5-11	8-28	10-22	16	69-82	77	6	38
1956	Yield	5-26	9-27	11-20	16	76-82	79	8	50
1956	10-hill	5-17	8-21	10-9	105	65-90	81	74	70
1957	Yield	4-30	8-5	8-7	28	79-86	84	27	96
1957	10-hill	5-18	9-6	10-10	90	75-90	86	85	94
1957	10-hill	5-25	9-9	10-12	47	76-90	84	39	83
1958	Yield	5-5	8-20	8-25	25	87-90	88	25	100
1958	Yield	5-5	9-15	10-6	25	85-89	87	25	100
1959	Yield	5-4	8-10	8-18	30	85-90	88	30	100
1959	Yield	5-4	8-10	10-8	30	85-90	87	30	100
1959	Yield	5-5	9-17	9-29	33	75-90	81	19	58
Totals					445			368	83

[1]Dates planting, harvesting, chipping began.
[2]Chips with a color index of 80 or higher are commercially acceptable.

TABLE 2.—*Chip color of potatoes grown in Alabama and cooked at Madison on arrival — 1957, 1958, 1959, 1960.*

Year tested	Kind of tess	Dates[1] Plant	Harvest	Chip	Varieties tested No.	Chip color index[2] Range	Mean	Varieties with index 80 or higher No.	Pct.
1957	Yield	2-7	6-4	..	26	75-87	81	18	69
1957	5-hill	2-7	6-5	..	111	69-90	80	66	59
1958	Yield	2-3	5-26	6-6	29	79-90	86	27	93
1958	5-hill	2-3	5-27	6-6	107	75-90	85	95	89
1959	Yield	2-18	5-26	6-1	22	75-89	84	20	91
1959	Yield	2-18	6-17	6-22	22	75-90	83	17	77
1959	Yield	2-18	5-26	6-1	27	74-89	84	24	89
1959	Yield	2-18	6-17	6-22	27	74-90	83	22	81
1959	5-hill	2-18	6-17	6-22	172	55-90	79	79	46
1960	Yield	2-2	5-18	5-23	41	72-87	81	27	66
1960	Yield	2-2	6-15	6-20	41	78-89	84	38	93
1960	5-hill	2-2	6-15	6-23	306	75-90	86	287	94
Totals					931			720	77

[1]Dates planting, harvesting, chipping began.
[2]Chips with a color index 80 or higher are commercially acceptable.

they were dug the internal temperature of some tubers was 38°. Despite his the chips made from 10 varieties in the test scored 80 or higher in color. These results are significant, showing that the tubers of some varieties were not affected, to an appreciable degree, but that others were affected adversely by the conditions in which they were harvested. The totals for the eleven tests reported in Table 1 show that the tubers of

368 of the 445 varieties tested or 83% produced commercially acceptable chips if fried on arrival from the harvest fields at Rhinelander.

Chips with good to excellent color can be made also from many varieties grown in Alabama if the tubers are chipped on arrival from the fields. The data for the Alabama tests, for the years 1957 to 1960 inclusive are given in Table 2. The chips made from the varieties in all 12 tests ranged from 55 to 90 in color with from 46 to 94% of the varieties in the individual tests producing chips with an index of 80 or higher. From a total of 931 varieties tested, 720 or 77% produced chips with commercially acceptable color. It is evident, from the data in Tables 1 and 2, that chips with good to excellent color can be made from many varieties if properly handled and chipped on arrival from the harvest fields from either Rhinelander or Alabama.

Chip color direct from 50° storage — Tuber samples from all the late harvested yield tests and the selections from the 10-hill rows grown at Rhinelander were stored from 9 to 18 weeks at 50° and chipped direct from storage. The data for these tests are given in Table 3. The chip color of the 8 tests ranged from 65 to 90 with from 20 to 83% of the varieties in the individual tests scoring 80 or higher. From a total of 1287 varieties tested, 457 or 36% produced chips with a color score of 80 or higher. It is evident that the tubers of many varieties will produce chips with commercially acceptable color after being stored from 9 to 16 weeks in a room with a constant temperature of 50° F. and chipped direct from storage.

Chip color — tubers stored at 42° — cured 4 to 5 weeks — One of the objectives of the research programs is to breed varieties that can be stored at 42° and reconditioned more rapidly than most of the standard varieties. It often takes 8 to 9 weeks at 70° to 80° to cure the tubers of some varieties, but chips with excellent color can be made from the tubers of some of the new selections after curing 4 weeks. Data for these tests for the year 1957 to 1959 are given in Table 4. Chips with excellent color were made from the tubers grown in all 9 tests reported. The percentage of those with an index of 80 or higher varied from 12 to 75. However, from 1363 varieties and seedling selections tested, chips with such indexes were made from the tubers of 331, or 24% of the total. It is evident that it is not difficult to breed varieties the tubers of which can be stored at 42° for from 9 to 12 weeks and produce good to excellent colored chips after 4 weeks curing at 70° to 80° F.

Increase of brown color in chips and rapidity of curing after 42° storage — In 1959, 62 high yielding seedling varieties, from which chips were made in 1958, that scored 80 to 90 in color after 16 weeks in storage at 42° and curing for 4 weeks, were grown in increase plots. Tubers from these plots were stored again at 42°. Chips were made from the tubers the day they were stored and every week in storage for 5 weeks. Other tuber samples of the same varieties were stored for 9 weeks, chipped on removal from storage and at weekly intervals for 4 weeks after transfer to the curing room. The object of these tests was twofold; to determine the increase in browning of the chips made from each variety as related to the time in storage, and to ascertain the time

TABLE 3.—*Chip color of potatoes grown at Rhinelander, Wisconsin and cooked at Madison after storage at 50° F. — 1957, 1958, 1959.*

Year tested	Kind of test	Time stored Weeks	Varieties tested No.	Chip color index[1] Range	Mean	Varieties with index 80 or higher	
1957	Yield	18	24	76-90	84	20	83
1958	Yield	12	27	71-89	81	15	56
1958	10-hill	12	455	65-90	78	146	32
1958	10-hill	12	55	70-89	78	16	29
1958	10-hill	12	51	72-90	83	40	78
1959	Yield	9	35	68-89	76	7	20
1959	Yield	9	26	73-88	80	15	58
1959	10-hill	9	614	65-90	77	198	32
Totals			1287			457	36

[1]Chips with a color index of 80 or higher are commercially acceptable.

TABLE 4.—*Chip color of potatoes grown at Rhinelander, Wisconsin and cooked at Madison after storage at 42° F. — 1957, 1958, 1959.*

Year tested	Kind of test	Time stored Weeks	Time cured Weeks	Varieties tested No.	Chip color index[1] Range	Mean	Varieties with index 80 or higher No.	Pct.
1957	Yield	12	4	24	75-88	81	16	67
1957	Yield	12	5	20	70-89	80	6	30
1957	Yield	12	4	24	75-89	81	18	75
1958	Yield	12	4	29	72-89	80	17	59
1958	10-hill	12	4	525	55-89	73	63	12
1959	Yield	9	4	35	71-86	76	8	23
1959	Yield	10	4	26	77-88	82	19	73
1959	10-hill	10	4	614	62-90	77	173	28
1959	10-hill	10	4	66	65-85	74	11	17
Totals				1363	55-90	76	331	24

[1]Chips with a color index of 80 or higher are commercially acceptable.

required for the tubers of each variety to condition after 9 weeks in storage. The data for these tests are given in Table 5.

The chips made from 47 of the varieties scored 80 or higher before they were placed in 42° storage. After 1, 2, 3, 4, 5 and 9 weeks storage acceptable chips were made from 17, 5, 4, 1, 0 and 0 varieties respectively. After storing 9 weeks and curing for 1 week the chips made from all varieties were still below 80 in color. After 2 weeks in the curing room 7 varieties scored 80 or higher. After 3 weeks reconditioning the number of varieties from which chips with acceptable color were made had increased to 16 and in 4 weeks to 19. Although varieties that required only 4 weeks curing would have several advantages over those that require 8 or 9 weeks, the indications are that a few varieties will recondition in 3 or even 2 weeks time after storage at 42°.

TABLE 5.—*Chip color of varieties grown in the increase plots at Rhinelander.*[1]

Time stored Weeks	Time cured Weeks	Varieties tested No.	Chip color index[2] Range	Mean	Varieties with index 80 or higher No.	Pct.
0	0	62	75-90	83	47	76
1	0	62	64-88	76	17	27
2	0	62	65-85	74	5	8
3	0	62	65-87	72	4	6
4	0	59	65-85	71	1	2
5	0	47	61-78	71	0	0
9	0	62	62-77	68	0	0
9	1	62	65-78	72	0	0
9	2	62	67-84	75	7	11
9	3	62	71-89	77	16	26
9	4	56	69-88	78	19	34

[1]Tubers were stored at 42°, chips made before storage and every week in storage for 5 weeks. Also stored 9 weeks at 42°, chipped on removal and each week for 4 weeks after transfer to 70° to 80° temperature. 1959.
[2]Chips with a color index of 80 or higher are commercially acceptable.

Reconditioning after storage at 38° — If potatoes are to be stored over the winter and well into the summer months a storage temperature lower than 42° is desirable. Tuber samples of the same 62 varieties that were stored at 42° were stored also at 38°. After about 18 weeks the potatoes were transferred to the curing room. Samples were chipped on removal from storage and at weekly intervals for 7 weeks thereafter. The data for these tests are given in Table 6. The chips made from the tubers directly after storage were very dark in color, ranging from 52 to 60 with an average of 58. After the tubers were transferred to the curing room, the chip color improved rapidly but the varieties differed greatly in their speed of curing. None of the varieties produced acceptable chips for the first 2 weeks although the chips made from some of them scored 77 after one week and 78 the second week. After 3 weeks the chips made from 6 varieties scored 80 or higher in color, after 4 weeks the number of varieties in this class had increased to 9, in 5 weeks to 15, in 6 weeks to 27 and in 7weeks to 28. The chips made from the other 34 varieties scored lower than 80 after 7 weeks curing in a temperature of 70° to 80°.

Reconditioning of Red Dot numbers after storage at 38° — Twenty-eight varieties that were given Red Dot numbers were stored about 14 weeks at 38° F., after which they were transferred to the reconditioning room. Samples of each were chipped on removal from storage and at weekly intervals for 7 weeks thereafter. The data for these tests are given in Table 7. The chips made from the tubers direct from storage were very dark. They ranged in color from 51 to 61 with an average of 57. In one week the chips of RD 10 scored 78, a color acceptable on some markets. In 2 weeks the chips made from RD 10 improved 1 point in color scoring 79. At this time RD 7 and RD 17 scored 81 and 80,

TABLE 6.—*Chip color of varieties of potato selected for increase, held in 38° storage for 18 weeks, cured in 70° to 80° F. and chipped at weekly intervals, 1959.*

Time stored Weeks	Time cured Weeks	Varieties tested No.	Chip color index[1] Range	Mean	Varieties with index 80 or higher	
18	0	62	52-60	58	0	0
18	1	62	61-77	67	0	0
18	2	62	65-78	70	0	0
18	3	62	62-89	74	6	10
18	4	62	66-84	75	9	15
18	5	62	66-88	76	15	24
18	6	62	70-88	79	27	44
18	7	62	71-89	79	28	45

[1]Chips with a color index of 80 or higher are commercially acceptable.

respectively. In 3 weeks the number of varieties from which chips were made with indexes of 80 or higher had increased to 6; in 4 weeks, to 13; in 5 weeks, to 13; in 6 weeks to 20; and in 7 weeks to 20. The best RD varieties in the group so far as speed of reconditioning is concerned were: 7, 8, 9, 10, 15 and 23. Only those tubers of the Kennebec cured slowly. The best chips made from this variety scored 75 after 7 weeks in the curing room.

SUMMARY

Red Dot Foods, Inc. grows, on its farms at Rhinelander and Waupaca, Wisconsin and near Mobile, Alabama about 40% of the potatoes required for its many chip factories. Future plans are for the company to grow and store a larger percentage of its yearly needs. With such a development in prospect the effects of storage temperatures and rapidity of reconditioning after removal from storage on chip color are given major emphasis in the potato research program.

From 20 to 25 thousand new seedlings, representing many crosses and a number of selfed lines are grown annually on the Research Farm at Rhinelander. In succeeding years selections from these are tested under various storage treatments. Varieties, early harvested, are chipped on arrival at the Madison laboratory direct from the fields. Advanced selections are stored at 50°, 42° and 38° for various periods of time.

Chips with satisfactory color were made from the tubers of hundreds of seedling varieties if fried on arrival from the harvest fields of Rhinelander or Alabama. Chips with commercially acceptable color were made from the tubers of many varieties after storage in a room with a constant temperature of 50° F. and chipped direct from storage. Chips with excellent color were made from the tubers of many varieties and seedling selections stored from 9 to 12 weeks at 42° and cured 4 weeks at 70° to 80°. The increase of brown color in chips and rapidity of curing after 42° storage varies with the variety. Chips with acceptable color were made from 4 varieties after storing 3 weeks and one variety

TABLE 7.—*Chip color of 28 Red Dot varieties and a Kennebec check after storage at 38° F. for about 14 weeks, chipping direct from storage and from the 70° to 80° curing room at weekly intervals for 7 weeks, 1959.*

Red Dot No.	0 Color index	Periods of time cured before chipping						
		1 Wk index Color	2 Wk index Color	3 Wk index Color	4 Wk index Color	5 Wk index Color	6 Wk index Color	7 Wk index Color
1	58	64	62	71	66	70	81	74
2	56	61	66	73	76	78	82	78
3	55	61	65	72	69	75	77	75
4	57	67	72	77	80	86	86	80
5	56	65	71	73	75	75	77	80
6	56	67	69	72	76	73	77	80
7	59	68	81	81	88	83	86	84
8	61	68	77	82	82	87	83	89
9	57	73	74	81	87	83	88	86
10	57	78	79	84	86	84	88	84
11	56	65	74	79	80	77	81	81
12	58	69	75	78	81	82	81	85
13	57	65	71	76	74	73	79	71
14	53	73	71	75	76	83	79	84
15	51	67	76	80	86	88	89	87
16	58	69	76	78	81	80	84	83
17	57	72	80	77	79	83	86	85
18	58	70	76	77	77	79	83	76
19	56	68	69	76	71	76	79	79
20	55	70	75	79	76	79	84	81
21	57	68	71	76	80	80	86	84
22	57	71	76	75	69	77	76	80
23	56	77	78	88	88	87	87	86
24	57	66	75	76	78	74	84	77
25	58	72	74	78	81	78	78	82
26	57	71	77	77	77	79	80	79
27	59	74	79	79	86	87	84	84
28	56	64	69	72	78	75	79	79
Kennebec	56	63	67	65	70	70	69	75
Mean	57	68	73	77	78	79	82	81
No. of varieties with index 80 or higher[1]	0	0	2	6	13	13	20	20

[1]Chips with a color index of 80 or higher are commercially acceptable.

after 4 weeks at 42°. The chips made from the tubers of 47 seedling varieties direct from 9 weeks storage at 42° or after 1 week in the curing room scored below 80 in color. However, after 2, 3 and 4 weeks in the curing room the chips from 7, 16 and 19 varieties, respectively, scored 80 or higher.

Tubers of 62 advanced seedlings were stored 18 weeks at 38° F. Samples of each were chipped on removal from storage and others at weekly intervals for 7 weeks. None of the varieties produced acceptable

chips for the first 2 weeks, but the chips made from some of them scored 77 after one week in the curing room and 78 the second week. Six varieties reconditioned satisfactorily in 3 weeks, 9 in 4 weeks, 15 in 5 weeks, 27 in 6 weeks and 28 in 7 weeks.

Twenty-eight Red Dot varieties were stored about 14 weeks at 38° F. Samples of each were chipped on removal from storage and at weekly intervals for 7 weeks. The chips made from the tubers direct from storage were very dark. After one week in the curing room the chips made from RD 10 scored 78, a color acceptable on some markets. In 2 weeks the chips made from RD 7 scored 81, those from RD 10 scored 79 and those those from RD 17 scored 80. In 3 weeks the number of varieties from which chips scoring 80 or higher was 6, in 4 weeks 13, in 5 weeks 13, in 6 weeks 20 and in 7 weeks 20. The best RD varieties in this group of 28, so far as speed of reconditioning is concerned were No's. 7, 8, 9, 10, 15 and 23. The tubers of Kennebec cured slowly. The best chips made from this variety scored 75 after 7 weeks in the curing room at 70° to 80° F.

THE IMPORTANCE OF THE SPRING MIGRANTS OF THE BUCKTHORN APHID IN THE SPREAD OF POTATO VIRUS Y[1]

W. A. SHANDS, R. E. WEBB AND E. S. SCHULTZ[2]

Most viruses of economic importance to potato seed production are transmitted by one or more species of aphids (1). Nonpersistent potato viruses A, Y, aucuba, and others are transmitted easily and efficiently to healthy plants during a short feeding period by the probing stylets of wingless aphids which have previously fed on virus-infected plants (3). Early current-season symptoms of virus infections in plants grown from seed stocks known to be free of most viruses cannot be attributed to the wingless aphids. These early-season infected plants usually occur at random in certain areas of affected fields which indicates that the infections were caused by the infiltration of viruliferous winged aphids at or about plant emergence. In northeastern Maine these are spring-migrant aphids.

Movement of spring migrants from the overwintering hosts of the four species of aphids[3] commonly infesting potatoes in northeastern Maine has been studied by Shands *et al* (2). This migration usually coincides with emergence of plants of the principal potato seed crop, but in some years starts even before the plants begin to come up. However, an insecticide program usually is not begun by most farmers until the plants are 4 to 6 inches tall or even later if the potato flea beetle, *Epitrix cucumeris* (Harr.) is not very abundant. Without early applications of an insecticide, spring migrants are able to establish colonies of wingless individuals.

The buckthorn aphid overwinters well and is ordinarily the most abundant species in potato fields during the early part of the field season in northeastern Maine. Therefore this aphid was selected as a test insect to determine the efficiency of its spring migrants in transmitting potato virus Y.

MATERIALS AND METHODS

Tubers of the Katahdin variety of potato were cut into five seed pieces. Four seed-pieces from each tuber were planted in an insect-proofed cage for infestation with viruliferous aphids. The fifth seed piece was grown in a separate insect-proofed cage as an index to the health of the tuber.

Naturally occurring stem-mother nymphs of the buckthorn aphid were caged in place on branches of the overwintering host, alder-leaved buckthorn *Rhamnus alnifolia* (L'Hér) by enclosing each infested branch in

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[2]Entomology and Crops Research Divisions, and Collaborator, Crops Research Division, respectively, Agricultural Research Service, United States Department of Agriculture.

[3]The buckthorn aphid *Aphis nasturtii* (Kltb.)
The potato aphid *Macrosiphum euphorbiae* (Thomas)
The green peach aphid *Myzus persicae* (Sulz.)
The Foxglove aphid *Myzus solani* (Kltb.)

a cage made of cotton scrim. In most instances there was a single stem-mother nymph in a cage. Cages were inspected occasionally to minimize the damage from possible predators. When the spring migrant forms began to mature, each cage was inspected on alternate days, and the winged aphids transferred to vials with an aspirator.

Virus Y-infected leaves of the Green Mountain potato served as the source of inoculum. Each leaf was cut into pieces ½-inch square, and placed in glass-covered refrigerator dishes. Immediately after each collection aphids were introduced into the dishes and held for 30 minutes at 55° F. for virus acquisition. The squares of leaf tissue bearing 5-15 aphids were placed on each of the four potato plants in each cage. After a 24-hour infection period, the aphids were killed with an insecticide.

Approximately 60 days after plant inoculation, the cages were removed and the plants inspected for symptoms of virus Y. Tubers were collected from apparently healthy plants and grown in the greenhouse as a final index to aphid-infection with virus Y.

Results and Discussion

Spring migrants of the buckthorn aphid proved to be effective vectors of virus Y. Table 1 shows that 62% of the test plants became infected in the 1956 inoculation trials and 48% in the 1957 trials, with an average of 54%.

Table 1.—*Efficiency of spring migrants of buckthorn aphid in transmission of potato virus Y at Presque Isle, Maine.*

Year	Number of plants[1] inoculated	Number of plants	
		Infected	Healthy
1956	52	33	20
1957	60	29	31

[1]Variety Katahdin; control plants healthy.

In northeastern Maine the greatest spread of aphid-transmitted virus diseases usually occurs during mid- and late summer when both wingless and winged aphids are most abundant in the potato fields. The amount of spread to occur during that period depends to a considerable extent upon the abundance of the disease reservoirs present. Prevalence of these reservoirs in midseason is determined largely by early-season abundance of diseased potato plants and spring-migrant aphids in the field.

Relatively few spring migrants mature on the primary hosts and fly to potatoes early in the season compared with the numbers of summer-dispersal forms which mature or are present on potatoes later in the season. Nevertheless those that do mature on the primary hosts are significant, as shown by the data in Table 2. The results of Shands and Simpson (unpublished data) show that the average colony productiveness of buckthorn aphid spring migrants is greater than that indicated in Table 2. Predators, chiefly larvae of syrphid flies, were responsible for the small numbers that matured in some of the colonies.

TABLE 2.—*Spring migrants of the buckthorn aphid maturing in caged colonies on alder-leaved buckthorn at Presque Isle, Maine.*

Year	Cage number	Total number of winged aphids
1956[1]	1	295
	2	150
	3	301
1957[2]	1	119
	2	92
	3	69
	4	186

[1]Collection dates June 24-July 6.
[2]Collection dates June 17-June 21.

The spread of viruses by spring migrants of some aphid species is influenced not only by their numbers but also by their well-recognized habit of making frequent, short flights between potato plants while feeding and depositing nymphs. The presence in midseason of potato plants that show primary symptoms of the disease and that are widely distributed throughout the field usually indicates early season spread by spring migrants.

These facts serve to emphasize the importance of and need for early-season control of the spring migrant aphids, especially before diseased plants can be recognized and removed.

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CYTOPLASMIC STERILITY IN DERIVATIVES OF *SOLANUM DEMISSUM*[1]

LEO A. DIONNE[2]

The hexaploid Mexican *Solanum demissum* Lindl. has been widely used as a source of resistance to *Phytophthora infestans* in potato breeding programs. *S. demissum* can be crossed directly with *Solanum tuberosum* only when used as a female parent. The resultant pentaploid F_1 hybrids are non-functional as males and usually produce seeds only if back-crossed with *S. tuberosum*. The male sterility of the back-crossed progeny persists even after ten or more successive generations of back-crossing.

Repeated and uninterrupted back-crossing is an efficient way to improve the horticultural characteristic of the derived progeny but recessive and incompletely dominant factors for resistance can be rapidly eliminated from breeding lines subjected to continuous back-crossing. Recessive and incompletely dominant factors could be strained by alternating the back-crossing program with selfing and/or sib-crossing. The high level of male sterility has prevented such an approach in programs based on the initial cross *S. demissum* x *S. tuberosum*; most programs of breeding for blight resistance from *S. demissum* are based on this initial cross.

Black has established part of his breeding on the initial cross *S. phureja* x *S. demissum* and has reported the successful isolation of male fertile lines from this initial cross (1). The improved fertility of this material could be attributed to the genomic balance of a tetraploid F_1 as contrasted to the pentaploid usually obtained from the cross *S. demissum* x *S. tuberosum*.

The validity of the genomic balance hypothesis could not be substantiated by work done at this laboratory. If genomic balance were primarily responsible for improved male fertility, the direction of the cross should not influence the ultimate results. Differences in the behavior of reciprocal crosses with regard to the production of fertile hybrid derivatives is best explained by the operation of cytoplasmic factors. Buck recently demonstrated that male sterility in hybrids of *Solanum verrucosum* was cytoplasmically conditioned (2). The purpose of this paper is to show that a similar cytoplasmic mechanism is also conditioning male sterility in derivatives of *S. demissum*.

MATERIALS AND METHODS

A clone (D_3-5) of *S. demissum* P. I. 161181 selected for high resistance to *P. infestans* was crossed reciprocally with a diploid hybrid of *S. chacoense* x *S. phureja*. The hybrids were examined for percentage of stainable pollen and attempts made to self and intercross them and to cross each with *S. tuberosum* as both male and female parent. The hybrids with *S. tuberosum* were then tested for their ability to self, sib-cross and to serve as male parents in crosses with *S. tuberosum*.

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[2]Potato Breeding Section.

A group of three tetraploid hybrids produced by crossing *S. demissum* with diploid species were obtained from Dr. R. H. Hougas of the Potato Introduction Station, Sturgeon Bay, Wisconsin, and treated in the same manner as the above.

Results

Seeds of the cross *S. demissum* x (*S. chacoense* x *S. phureja*) were produced without any special manipulation but the reciprocal was only obtained by supplementary hormonal treatment of the ovaries (3). Twelve tetraploid hybrids of the cross (*S. chacoense* x *S. phureja*) x *S. demissum* were obtained. The reciprocal of this cross yielded six tetraploid, two pentaploid and one triploid seedling. The triploid and pentaploids were discarded and all subsequent work done with tetraploids only.

The percentage of stainable pollen in the F_1 varied from three to twenty-eight per cent and did not appear to be influenced by the direction of the cross. Most of the seedlings that had *S. demissum* as a male parent produced some seeds from selfing and appreciable quantities of seeds by intercrossing. One seedling of this cross (XD1-8) averaged five seeds per berry when selfed. This seedling and two siblings were also slightly functional as male parents in crosses with *S. tuberosum* but only when the *S. tuberosum* ovaries were treated with 2,4-D or 2,4,5-T after pollination (3). One seedling of the reciprocal cross was capable of being selfed and this seedling could also pollinate its sibs, but none was functional as males in crosses with *S. tuberosum*.

Three hundred and ninety-six seedlings of XD1-8 selfed were grown to maturity. Six of these were highly fertile, and were easily selfed and set fruit as freely as *S. demissum* without any manipulation. These six plants were found to be hexaploids and were discarded.

Four hundred and two seedlings were grown from intercrosses of the XD1-8 siblings. Four hexaploids were the only highly self-fertile progeny in the population.

Fifty-two seedlings were grown from the cross XD1-8 x Green Mountain and thirty from the cross XD1-8 x Katahdin. The only limitation on the male fertility of these seedlings was a failure to produce stainable pollen by some clones. Most could be selfed, they were readily intercrossed and were freely functional as males in crosses with *S. tuberosum*.

Four siblings of XD1-8 were also crossed with Katahdin and ten seedlings of each cross were grown to flowering and tested as pollen parents in crosses with *S. tuberosum* varieties. These behaved essentially in the same manner as the XD1-8 crosses; that is, the seedlings having good quantities of stainable pollen were all functional as males.

Three seedlings of the cross *S. demissum* x (*S. chacoense* x *S. phureja*) were crossed with Katahdin and ten seedlings grown from each cross. None of these populations resulted in functional males in crosses with *S. tuberosum*, although a number of seedlings produced ample quantities of stainable pollen. Crosses of the three Wisconsin hybrids, *S. demissum* x *S. simplicifolium*, *S. demissum* x *S. soukupii* and *S. demissum* x *S. phureja* were crossed with Katahdin and ten seedlings grown from each cross; these also failed to produce any seedlings that were functional as male parents in back-crossing to *S. tuberosum*.

CONCLUSIONS

The results of this study indicate that the almost universal occurrence of male sterility in crosses of *S. demissum* with species of *Tuberosa* or *Commersoniana* is attributable to the interaction of a cytoplasmic factor or factors in *S. demissum* with nuclear factors contributed by the male parents. The use of tetraploid F_1 hybrids does not of itself eliminate the functional male sterility of the derivatives. Male sterility can apparently only be eliminated by avoiding the use of *S. demissum* as a female parent in the initial crosses. In direct crosses with *S. tuberosum* this is nearly if not impossible, but crosses with *S. demissum* as the male parent with diploids, as females, are not too difficult.

The cytoplasmically conditioned sterility of the *S. demissum* derivatives is not associated with the production of abortive pollen grains. Many hybrid derivatives of *S. demissum* as female parent, produce high percentages of stainable pollen but this pollen is non-functional. On the other hand the production of stainable pollen is a good index of the usefulness (as male parents) of *S. demissum* derivatives that have had that species as a pollen parent in the initial cross.

The appearance of one hybrid of *S. demissum* (as female parent) that produced pollen which functioned in certain combinations is difficult to explain unless the diploid male parent in some manner failed to transmit the nuclear factor(s) required to inactivate the pollen in the presence of the cytoplasmic factor(s). The re-establishment of male sterility in the hybrids of this seedling with *S. tuberosum* gives some support to this hypothesis.

The usefulness of pollen fertile *S. demissum* derivatives obtained from crossing diploids with *S. demissum* in the initial cross has been demonstrated for extracting recessive and incompletely dominant factors from *S. demissum*. This phase of the work will be discussed in a subsequent paper.

SUMMARY

The cross *S. demissum* x *S. tuberosum* has been the basis for many programs of breeding for resistance to *Phytophthora infestans*. The F_1 of this cross and subsequent back-crosses to *S. tuberosum* are generally non-functional as male parents; uninterrupted back-crossing is therefore obligatory in programs based on this initial cross. Since recessive and incompletely dominant factors are likely to be lost by continuous back-crossing, the male sterility of such hybrids can be a serious disadvantage. The initial cross *S. demissum* x *diploid species* results in similar non-functional males when crossed with *S. tuberosum*. However, when F_1 hybrids of the reciprocal cross (*diploid species* x *S. demissum*) are crossed with *S. tuberosum*, many of the resultant hybrids are highly functional as males. These hybrids can be selfed, sib crossed and used as male parents in crosses with *S. tuberosum*. This difference in the behavior of reciprocal crosses indicates that male sterility in *S. demissum* derivatives is cytoplasmically conditioned.

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EFFECTS OF pH OF DIPPING SOLUTIONS ON THE QUALITY OF PREPEELED POTATOES[1]

B. L. AMLA AND F. J. FRANCIS[2]

Commercial formulations available for control of discoloration in prepeeled potatoes usually have several other ingredients as well as the active sulphite compounds. Compounds such as citric acid, sodium carbonate and wetting agents are sometimes added and they serve several purposes. The first two act as fillers or diluents to allow the manufacturer to standardize the amount of sulphur dioxide available from several types of compounds. They also provide some buffer capacity to maintain the pH of the dipping solution at about 5 to 6 which is considered, apparently, to be the optimum range for solution stability and quality of the treated potatoes.

Discoloration in prepeeled potatoes is enzymatic in nature and the polyphenolase enzyme would be expected to show an optimum activity with pH. However, the optimum enzyme activity would be the least desirable from a prepeeling point of view. Dawson and Tarpley (3) indicated that there was little difference in activity of mushroom tyrosinase on catechol between pH 5.5 and 7 but in systems buffered below 5, the enzyme activity was decreased. According to Rozental and Zakrzewska (9) the optimum pH for tyrosinase activity in potatoes was about 8 in phosphate buffer. Several attempts have been made, without much success, to control discoloration in prepeeled potatoes by using a dipping solution with a pH unfavorable to tyrosinase activity. Li (7) and Westcott (13) showed that potatoes treated with 1 and 2% m-phosphoric acid, sulfuric acid, hydrochloric acid, oxalic acid or citric acid protected the potatoes from discoloration for a period of 2-4 days at 38-46° F. Obviously this was not long enough and the increased acidity introduced other problems, such as excessive exudation, which lowered the quality of the product. However, it may be possible to augment the action of the sulphite compounds by changing the acidity of the solution. This paper is concerned with the effect of sulphite solutions of different pH values on the quality of prepeeled potatoes.

MATERIALS AND METHODS

Idaho, Russet Burbank potatoes were purchased through regular commercial channels for this work. The potatoes were hand peeled, cut into French-fry style strips and kept immersed in tap water until treated. The potato strips were pressed between dry cloth towels to remove the excess moisture, dipped in the appropriate solution for 60 seconds and drained for five minutes before packing in Cryovac[3] or polyethylene[4] bags.

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[2]University of Massachusetts, Amherst, Massachusetts.

[3]5″x16″ bags obtained through the courtesy of the Cryovac division of W. R. Grace & Co., Cambridge, Mass.

[4]2″x4″x12″ bags of 1 mil polyethylene obtained through the courtesy of the Shellmar Betner division of the Continental Can Co., Newark, Ohio.

The sulphite solutions were prepared by dissolving the required amount of sodium bisulphite in the appropriate buffer solution. The buffer solutions of pH 4 were prepared from mixtures of 0.1 M citric acid and 0.2 M dibasic sodium phosphate solutions. The buffers of pH 6, 7, and 8 were prepared from mixtures of 0.2 M. monobasic sodium phosphate and 0.2 M. dibasic sodium phosphate solutions. The buffers of pH 10 were prepared from mixtures of 0.2 M. sodium carbonate and 0.2 M. sodium bicarbonate solutions.

The pH of each buffer solution was recorded with a Beckman Model G pH meter before and after the addition of the bisulphite. The pH of the buffer solutions changed upon addition of the bisulphite salt and the extent of this change depended upon the amount of salt added. No effort was made to readjust the pH of the dipping solutions after the addition of bisulphite except in one series (Tables 3 and 4) where the potatoes were packed in polyethylene bags and stored at 32-34° F. In this case the buffer solutions were readjusted to the original pH value by the addition of dry buffer salts.

The exudation was measured by blotting the bag and contents with a dry paper towel and weighing before and after according to the method developed for carrots (5). The alcohol determinations were made by the method of Shupe and Dubowski (11)(1). The softness determinations were made with a Universal Precision Penetrometer[5] with 150 grams weight on the bar.

The color determinations were made visually on the unopened bags and on the individual strips with a Gardner manual model Color and Color-Difference Meter.[6] The half-inch strips were too narrow to fit over the small area aperture (½ inch diam.) of the instrument without loss of light. Therefore an adapter was made to fit over the small area aperture. It consisted of a metal plate, painted black, with a ¼ x ½ inch rectangular opening in the center. Readings obtained on one inch cubes of fresh potato tissue, with and without the adapter, showed that the adapter introduced an error into the absolute color values. Even when the instrument was standardized against the same tile (Rd = 61.5; a = −1.9, b = +23.1) with and without the adapter in place, the readings without the adapter were 6.7, −0.1 and +1.9 higher for Rd, a and b respectively. The above figures were the arithmetic means of ten determinations which showed a range of 4.7 to 9.4, −0.1 to 0.6 and −0.9 to 3.7 for Rd, a and b, respectively. However, despite the change in absolute color values with the adapter, the colors were comparable from one experiment to the next.

The calculations of least significant differences (L.S.D.) were made by the method of Tukey (12).

Results and Discussion

Discoloration.

Visual and objective data on discoloration of potato strips are presented in Tables 1 and 2 for samples that had been stored in polyethylene bags for 10 and 16 days at 40-42° F. One thousand ppm sulphur dioxide

[5]Manufactured by the A. S. Aloe Co., St. Louis 3, Mo.
[6]Manufactured by the Henry A. Gardner Co., Bethesda 14, Md.

TABLE 1.—*Effect of pH variation of the dipping solutions on the quality of prepeeled potatoes packed in polyethylene bags and stored at 40-42° F. for 10 days.*

Sulphur dioxide conc. ppm	pH[1]	Color				Softness[4] mm	Exudation % g/100 g
		Visual[2]	Gardner reading[3] Rd	a	b		
1000	4.1	0	37.9	—2.5	+14.4	33.7	0.1
	5.7	++	35.9	—1.5	+14.4	34.6	0.0
	6.8	++	36.6	—2.2	+13.9	36.3	0.1
	7.5	++	34.0	—1.9	+14.4	33.2	0.1
	9.2	++	27.7	—0.6	+15.7	31.9	0.2
(no buffer)	3.4	++	34.3	—2.1	+14.3	32.1	0.3
2000	4.2	+	31.9	—1.2	+16.5	44.4	2.5
	5.7	++	26.5	+2.2	+16.8	40.3	3.1
	6.6	++	32.1	—0.7	+15.5	36.9	2.8
	7.2	++	27.2	—0.7	+15.8	35.9	1.0
	7.8	++	25.6	+3.5	+15.4	36.4	1.7
(no buffer)	3.7	++	32.2	—1.1	+14.7	42.5	2.9
4000	4.2	0	40.6	—4.8	+12.6	46.4	9.9
	5.4	0	41.1	—4.5	+12.3	42.0	6.4
	6.5	0	41.9	—4.5	+13.1	46.0	4.7
	6.7	0	39.2	—4.8	+12.6	50.0	3.1
	6.8	0	40.9	—4.5	+12.2	38.8	3.0
(no buffer)	3.8	0	43.1	—4.4	+11.5	41.6	3.8
0	4.2	++	26.3	—1.2	+15.1	34.4	0.8
Controls	5.9	++	20.9	—0.1	+13.6	33.4	0.9
	7.0	++	21.8	..	+13.6	37.5	0.6
	7.9	++	19.3	..	+12.9	37.5	0.4
	9.9	+++	19.5	..	+12.0	32.5	0.1
(no buffer)	..	++	24.9	..	+12.6	33.6	0.1
L.S.D. (5% level)			3.8			7.6	

[1]pH of the dipping solutions was recorded after the addition of sodium bisulphite.
[2]A zero, one plus, two plus and three plus signs indicate respectively no, mild, moderate and excessive discoloration.
[3]A high value for Rd indicates a whiter product. Each datum represents the average of ten readings.
[4]A high reading indicates a softer product. Each datum represents the average of ten readings.

was adequate to preserve the white color of potatoes dipped in the solution of pH 4.1, for 10 days at 40-42° F. but not for 16. The samples dipped in 2000 ppm sulphur dioxide at pH 4.2 showed mild discoloration at 10 days and none at 16 (Tables 1 and 2). Samples dipped in solutions of all the other pH values tested were discolored at 10 and 16 days. The samples treated with 4000 ppm sulphur dioxide at all pH values showed no discoloration. The samples treated with 0, 1000, and 2000 ppm sulphur dioxide showed a distinct increase in discoloration (Table 1) with an increase in pH and the samples with buffer alone discolored more than those treated with sulphur dioxide. This indicated that the inhibitory effects of sulphur dioxide and acidity were probably acting in conjunction.

TABLE 2.—*Effect of pH variation of the dipping solutions on the quality of prepeeled potatoes packed in polyethylene bags and stored at 40-42° F. for 16 days.*

Sulphur dioxide conc. ppm	pH[1]	Visual observations[2]			Alcohol[3] mg/100 g	pH of tissue after storage[4]
		Color	Softness	Exudation		
1000	4.1	+	++	+	2	5.9
	5.7	++	++	+	..	5.9
	6.8	++	0	0	..	6.0
	7.5	++	+	+	..	6.1
	9.2	++	++	+	9	6.3
(no buffer)	3.3	++	0	0	..	6.1
2000	4.2	0	+++	+++	122	5.6
	5.7	++	+++	+++	107	5.7
	6.7	++	++	++	96	5.7
	7.2	++	++	++	79	5.8
	7.8	++	++	++	57	6.0
(no buffer)	3.7	++	++	++	51	5.8
4000	4.2	0	+++	+++	183	5.0
	5.4	0	+++	+++	192	5.3
	6.5	0	+++	+++	176	5.5
	6.7	0	++	++	176	5.6
	6.8	0	++	++	186	5.6
(no buffer)	3.8	0	++	++	195	5.4
0	4.2	++	0	0	3	6.3
Controls	5.9	++	+	+	25	6.3
	7.0	++	+	+	..	6.1
	8.0	++	++	++	57	6.6
	9.9	++	++	++	16	6.6
(no buffer)	..	+++	0	0	..	6.1

[1]pH of the dipping solution recorded after addition of sodium bisulphite.
[2]A zero, one plus, two plus and three plus indicate respectively, no, mild, moderate and excessive discoloration, softness or exudation.
[3]Each datum represents the average of duplicate determinations.
[4]pH recorded on the macerated tissue after storage.

There were several anomalies noted in the data on discoloration. For example, one sample treated with 2000 ppm sulphur dioxide at pH 4.2 showed mild discoloration after 10 days at 40°-42° F. while another sample with the same treatment showed no discoloration at 16 days. This apparent reversal was noted in several other examples (1) but the effect was very small. The Rd values generally were a good indication of darkening but there were also small hue changes as well. In Table 1 the samples treated with 2000 ppm sulphur dioxide at pH values 7.2 and 7.8 showed a difference in Rd of only 1.6 units but there was also a difference in hue (1.6 $\tan^{-1}{}^{a}/_{b}$ units) (4) as judged by the "a" and "b" data. The samples treated with the solutions of pH 7.8 were redder. The hue change in general was fairly small but it was not surprising that it could be demonstrated as Nelson and Dawson (8) pointed out that pinkish and reddish intermediates were formed in potatoes as intermediates in melanin formation.

TABLE 3.—*Effect of pH variation of the dipping solutions on the quality of prepeeled potatoes packed in polyethylene bags and stored at 32-34° F. for 10 days.*

Sulphur dioxide conc. ppm	pH[1]	Color Visual[2]	Color Rd[3]	Softness[3] mm	Exudation % g/100 g
1000	4.0	0	39.0	35.9	0.1
	6.0	0	38.7	35.9	0.1
	7.0	0	36.4	34.5	0.1
	8.0	0	36.5	35.2	0.2
	10.0	0	37.4	33.2	0.1
(no buffer)	3.4	0	39.5	33.6	0.1
2000	4.0	0	39.3	36.5	1.2
	6.0	0	38.2	38.6	0.2
	7.0	0	36.7	34.2	0.2
	8.0	0	35.9	37.0	0.1
	10.0	+	35.8	36.4	0.3
(no buffer)	3.5	0	41.1	34.0	0.1
4000	4.0	0	41.1	57.3	13.5
	6.0	0	36.2	48.7	8.3
	7.0	0	34.4	37.9	1.8
	8.0	0	38.8	35.9	0.3
	10.0	+	36.5	38.0	1.2
(no buffer)	3.7	0	38.6	36.7	0.5
0	4.0	++	26.8	32.7	0.2
Controls	10.0	+++	19.0	31.6	0.2
(no buffer)	..	++	24.3	32.7	0.1
L.S.D. (5% level)			2.98	5.22	

[1]pH recorded after the addition of sodium bisulphite and subsequent adjustment of pH with dry buffer salts.
[2]A zero, one plus, two plus, and three plus indicate respectively no, mild, moderate and severe discoloration.
[3]Each datum represents the average of ten readings.

In Tables 3 and 4, data are provided on discoloration at 32-34° F. for samples dipped in solutions with the pH readjusted to compensate for the change introduced by the addition of bisulphite. The same trends were evident in Tables 1 and 2 except to a much lesser degree. This would be expected in view of the lower storage temperature because Rozental and Zakrzewska (10) pointed out that the optimum temperature for polyphenolase activity was about 104° F.

In Tables 5 and 6 data are provided on discoloration for samples in Cryovac bags. This situation imposed a third limiting factor for discoloration in addition to acidity and sulphite, namely, a reduced oxygen tension. The Cryovac film allowed less gaseous diffusion and therefore there was less oxygen available for reaction with the substrate. In this situation, less sulphite was necessary for control of discoloration, but the same trends were evident as in the preceding tables. The degree of darkening increased with increasing pH and decreasing concentration of sulphite. Apparently

TABLE 4.—*Effect of pH variation of the dipping solutions on the quality of prepeeled potatoes packed in polyethylene bags and stored at 32-34° F. for 16 days.*

Sulphur dioxide conc. ppm	pH[1]	Visual observations[2] Color	Softness	Exudation	Alcohol[3] mg/100 g	pH of tissue after storage[4]
1000	4.0	0	0	+	..	6.1
	6.0	0	0	0	..	6.1
	7.0	0	0	0	..	6.1
	8.0	+	0	0	..	6.2
	10.0	0	0	0	..	6.2
(no buffer)	3.4	0	0	0	..	6.1
2000	4.0	0	0	+	26.0	5.9
	6.0	0	0	+	17.4	5.9
	7.0	0	0	+	26.5	6.0
	8.0	0	0	0	..	6.2
	10.0	+	0	0	2.2	6.3
(no buffer)	3.5	0	0	0	..	6.1
4000	4.0	0	+++	+++	14.5	4.6
	6.0	0	++	++	44.5	5.6
	7.0	0	+	+	68.2	5.8
	8.0	0	0	+	72.0	6.0
	10.0	0	0	+	84.6	6.2
(no buffer)	3.7	0	0	+	34.0	5.9
0	4.0	++	+	+	40.0	6.0
Controls	10.0	+++	0	0	..	6.1
No buffer		++	0	0	..	6.1

[1]pH of the dipping solution recorded after addition of sodium bisulphite.
[2]A zero, one plus, two plus and three plus indicate respectively, no, mild, moderate and excessive discoloration, softness or exudation.
[3]Each datum represents the average of duplicate determinations.
[4]pH recorded on the macerated tissue after storage.

all three limiting factors for discoloration were acting in conjunction for the samples in Cryovac bags.

There appeared to be no advantage in using sulphite solutions buffered on the alkaline side from any of the quality factors studied in this paper. There would even be a slight disadvantage as the alkaline pH values would be closer to the optimum pH for tyrosinase activity.

Softness.

The data in Tables 1 and 2 show a distinct trend towards a greater degree of softening with increased levels of sulphite. This effect was pointed out previously with sulphite solutions in conjunction with phytic acid (1). There was also a trend towards greater softness with decreasing pH but this effect was only significant at the 5% level for samples treated with 2000 ppm sulphur dioxide. The same trend toward increased softness with increasing levels of sulphur dioxide and decreasing pH was evident in Tables 3 and 4 particularly with 4000 ppm sulphur dioxide. The same trends were not evident in Tables 5 and 6 probably because of

TABLE 5.—*Effect of pH variations of the dipping solutions on the quality of prepeeled potatoes packed in Cryovac bags and stored at 32-34° F. for 10 days.*

Sulphur dioxide conc. ppm	pH[1]	Color Visual[2]	Color Rd[3]	Softness mm	Exudation % g/100 g
250	4.2	0	37.7	35.8	0.1
	5.8	++	35.4	34.0	0.1
	6.9	++	33.6	35.7	0.4
	7.7	++	28.8	34.1	0.1
	9.9	++	21.7	36.0	0.4
(no buffer)	3.7	0	39.2	34.1	0.2
500	4.3	0	39.6	32.9	0.3
	5.5	0	38.3	36.1	0.2
	6.8	0	38.4	38.8	0.2
	7.8	+	37.6	38.3	0.3
	9.7	+	37.2	39.3	0.6
(no buffer)	3.7	0	38.7	41.4	0.3
1000	4.3	0	37.4	38.8	0.5
	5.7	0	40.2	38.2	0.4
	6.7	0	39.2	37.3	0.2
	7.3	0	36.9	36.3	0.3
	9.2	0	37.8	44.4	0.2
(no buffer)	3.3	0	38.9	36.8	0.2
0	4.3	++	29.8	36.9	0.3
Controls	5.9	++	25.4	39.1	0.9
	70	++	24.1	41.0	0.6
	8.0	++	23.9	41.0	0.2
	10.0	+++	21.9	38.4	0.1
(no buffer)	..	++	21.8	39.0	0.2
L.S.D. (5% level)			4.3	7.3	

[1]pH measured after addition of sodium bisulphite.
[2]A zero, one plus, two plus, and three plus indicate respectively no, mild, moderate and excessive discoloration .
[3]Each datum represents the average of ten readings.

the lower levels of sulphite. The level of sulphite was much more important in softening than the pH of the dipping solution.

Exudation.

The degree of exudation usually correlated with the degree of softening because excessive liquid loss from the cells produced flaccid tissue. The data in Tables 1, 2, 3 and 4 indicate that the amount of exudation increased with the level of sulphite, and with the decrease in pH. At 1000 ppm sulphur dioxide, the effect of pH on exudation was insignificant. However, with 2000 and 4000 ppm the degree of exudation increased markedly in the lower pH range. This effect alone would probably preclude the use of sulphite solutions buffered at lower pH values.

The increase in exudation at the low pH ranges was not observed with the unbuffered solutions which had a pH value lower than the

TABLE 6.—*Effect of pH variation of the dipping solutions on the quality of prepeeled potatoes packed in Cryovac bags and stored at 32-34° F. for 16 days.*

Sulphur dioxide conc. ppm	pH[1]	Visual observations[2] Color	Softness	Exudation	Alcohol[3] mg/100 g	pH of tissue after storage
250	4.2	0	0	0	86.0	5.6
	5.8	++	0	0	90.6	5.7
	6.9	++	0	0	70.8	5.7
	7.7	++	0	0	55.0	5.8
	9.9	++	0	0	76.0	5.9
(no buffer)	3.7	+	0	0	98.0	5.9
500	4.3	0	0	0	88.2	5.7
	5.5	0	0	0	116.6	5.7
	6.8	0	0	0	102.5	5.7
	7.6	+	0	0	92.5	5.8
	9.7	++	0	0	83.8	5.9
(no buffer)	3.7	0	0	0	91.0	5.6
1000	4.3	0	0	0	83.8	5.7
	5.7	0	0	0	90.0	5.7
	6.7	0	0	0	96.0	5.7
	7.3	0	0	0	91.3	5.7
	9.2	0	0	0	73.4	5.8
(no buffer)	3.3	0	0	0	94.4	5.6
0	4.3	++	0	0	103.0	5.6
Controls	5.9	++	0	0	74.8	5.4
	7.0	++	0	0	95.1	5.5
	8.0	++	0	0	95.1	5.7
	10.0	+++	0	0	78.1	5.7
(no buffer)	..	++	++	++	55.0	5.9

[1]pH recorded after addition of sodium bisulphite to buffer solution.
[2]A zero, one plus and three plus indicate respectively no, mild, moderate and excessive discoloration, softness or exudation.
[3]Each datum represents an average of duplicate determinations.

buffered solutions. Neither was the increase particularly evident in Tables 5 and 6 where the sulphite levels were much lower. However, the increase in exudation with decreasing pH was not marked in the buffered samples without sulphite. These results suggest that there was an osmotic effect due to total salt concentration which increased the exudation particularly in the presence of high concentrations of sulphite. This may be an indication of tissue injury. There was another anomaly in the data on exudation because the observation (6) that storage in Cryovac bags increased exudation was not evident in these experiments. The reason for this is not clear at the present time but it may have been due to one or more of a number of factors which are known to influence the degree of exudation. The acidity, sulphite, and total salt level of the dipping solution, length of immersion time (6) and microbiological population (6) will all have some influence. Probably the variety, year and cultural conditions will also affect this phenomenon.

Alcohol.

The data in Tables 2 and 4 on alcohol content show a clear cut increase with increasing levels of sulphite. In Table 6, the relationship was not so evident because all samples had a relatively high alcohol content. The influence of pH value on alcohol content was not as clear. In Table 2, the samples treated with 2000 ppm sulphite showed a decrease in alcohol as the pH level was increased, but the unbuffered samples with a low pH had a low alcohol content. The samples treated with 4000 ppm sulphite did not show a pH effect but the alcohol levels for all samples in this series were very high. The alcohol content may be an indication of tissue injury due to a combination of pH, sulphite and salt level.

The data for effect of pH on alcohol content in Table 4 is exactly the opposite of that in Table 2. The samples treated with 1000 and 2000 ppm sulphite contained little alcohol but the samples treated with 4000 ppm sulphite showed an increase in alcohol content with increasing pH. Again the unbuffered samples had a low alcohol content. The overall alcohol contents for the samples at 32-34° F. (Table 4) were lower than those at 40-42° F. (Table 2) and this would be expected in view of the lower temperature. The samples at the lower temperature would also have more oxygen available as the respiration rate of the potatoes would be lower, but this effect is not likely to be important. Sulphur dioxide solutions are known to have a bacteriostatic effect which increase with decreasing pH (9) and this could influence the microbiological population which in turn could influence the alcohol content. However, the significance of the microbiological effect will not be apparent without further information. This will be the subject of another paper.

The effect of pH of the dipping solutions on alcohol content may be related to tissue injury. Probably any factor which contributed to tissue injury such as anaerobic respiration (2), sulphite level, and microbiological population (6) would influence the alcohol content. It should be noted that alcohol levels above 40 mg./100 g. in the raw potato strips would probably adversely affect the flavor of the cooked mashed product (2).

Tissue pH

Data on the pH of the macerated tissue after storage are presented in Tables 2, 4 and 6. It is obvious that most of the treatments had little effect on the pH of the whole tissue. Only where there was substantial tissue injury as evidenced by excessive exudation and softening (Table 4) was the pH of the macerated tissue appreciably lower. The dipping solutions exerted primarily surface effects but apparently they can have considerable influence on the quality of the product.

Summary and Conclusions

Prepeeled French-fry style potato strips were treated with varying concentrations of sodium bisulphite solutions buffered at six pH values from 4 to 10 and stored in polyethylene and Cryovac bags for 10 and 16 days at 32 to 34° F. and 40 to 42° F. Quality factors such as discoloration, softness, exudation, alcohol content and pH value were measured for each sample.

The degree of discoloration was decreased with higher levels of sulphite, lower oxygen tensions, lower pH value and lower temperature, indicating that all four factors were probably acting in conjunction to lower the level of tyrosinase activity.

The degree of softness was increased at the lower pH levels but the effect was relatively small.

The amount of exudation was markedly increased at pH levels below 5 particularly in the presence of high concentrations of sulphite. This factor alone would preclude the use of dipping solutions buffered below 5 in spite of the advantage in discoloration control. The exudation was also increased with higher concentrations of dissolved salts probably due to osmotic effects.

The alcohol content of the tissue showed a variable effect with different pH values and this may be an indication of tissue injury.

The optimum pH of the dipping solutions for prepeeled potatoes is in the range of 5.5 to 6.5.

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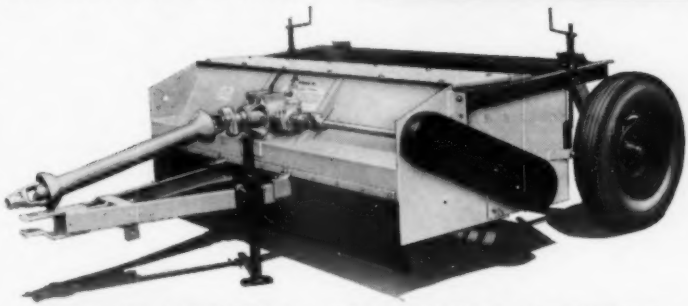

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NEWS AND REVIEWS

CALL FOR PAPERS

The 45th Annual Meeting of the Potato Association of America will be held at Wenatchee, Washington, July 26-28th, 1961.

Please send titles of papers to be presented at this annual meeting to Richard L. Sawyer, Long Island Vegetable Research Farm, Cornell University, Riverhead, New York, by May 15. Along with the title please include: (a) approximate time required to present your paper, (b) if an illustrated talk, the size of the slides to be used, and (c) the names and official addresses of the authors as you wish them to appear on the program. As has been our custom, we will again distribute mimeographed abstracts of these papers to members attending the annual meeting. These abstracts will be published in the American Potato Journal. Therefore, abstracts should accompany the titles of the papers. Abstracts should not exceed 250 words. Presentation of papers should not exceed 15 minutes, and the use of 2 x 2 slides is preferred.

We would like to receive good papers concerned with problems in potato physiology, breeding, diseases, production, quality, nutrition, storage, transportation, processing and marketing.

Your cooperation in sending the titles and abstracts as early as possible will aid in the mimeographing of these abstracts and the prompt preparation and printing of programs. Titles and abstracts received after our deadline of May 15 may not be accepted. Please bring this notice to the attention of your students and colleagues.

RICHARD L. SAWYER, *Secretary*
Potato Association of America
L. I. Vegetable Research Farm
Riverhead, New York

USDA STUDIES MARKETING MARGINS FOR FALL POTATOES

The marketing margin was higher for Idaho, Russet Burbank potatoes than for other varieties of fall potatoes sold in four cities during a test period, according to a report issued recently by the U. S. Department of Agriculture. The marketing margin is the difference between the price the grower receives and the price the consumer pays.

Researchers in USDA's Agricultural Marketing Service studied prices of Idaho Russet potatoes in Atlanta, Chicago, Los Angeles, and New York in four seasons. They also studied prices for four other varieties in these cities: Atlanta, Round White potatoes from the Northeast; Chicago, Pontiac potatoes from the Red River Valley of North Dakota-Minnesota; Los Angeles, California Long Whites; New York City, potatoes of the Katahdin-Chippewa type from Long Island and Maine.

The study is part of a program of continuing research designed to provide information on the farm-to-retail price spread for food products.

A free copy of Marketing Research Report No. 450, "Marketing Margins for Fall Potatoes," can be obtained from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

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COOPERATIVE LEADER FILLS POST IN COMMODITY STABILIZATION SERVICE

Frank W. Hussey of Maine, a former president of the National Council of Farmer Cooperatives, is now serving as Deputy Administrator for Operations, Commodity Stabilization Service, Secretary of Agriculture Orville L. Freeman recently announced.

In 1958 the Potato Association of America honored Mr. Hussey by giving him honorary life membership in recognition of his outstanding service to the potato industry.

Mr. Hussey, 58, was executive vice-president of the Maine Potato Council from 1955-1960. Prior to this he was president of Maine Potato Growers, Inc., a cooperative marketing association he helped organize in 1932.

He was a potato grower himself for 30 years—from 1925-1955—and also raised poultry and beef cattle.

Mr. Hussey served as president of the National Council of Farmer Cooperatives in 1953-1954.

From 1937-1944 he was a member of the Maine Agricultural Conservation Committee, now the State Agricultural Stabilization and Conservation (ASC) Committee.

THIRTEEN NUTRITION FELLOWSHIPS ESTABLISHED BY FOOD INDUSTRY AT COLUMBIA UNIVERSITY

A critical shortage of trained nutritionists and food technologists in the underdeveloped countries is being attacked through a $78,000 grant by seven major food processors of the Unitd States. The grant will bring thirteen foreign students to study at Columbia University's Institute of Nutrition Sciences, President Grayson Kirk of the University announced recently.

Dr. Kirk disclosed that the students, especially qualified and selected for the project, will be enrolled in Columbia's recently established Institute of Nutrition Sciences under a system of fellowships set up by the seven firms. The program is designed to train leaders who, on return to their homelands, can train others and develop effective public health and nutrition programs in the underdeveloped areas, with particular emphasis on those countries in which malnutrition is a significant problem.

"In this manner," said Dr. W. H. Sebrell, Jr., director of the Institute, "the serious shortage of trained personnel in the underdeveloped countries can be eased, and eventually corrected."

The grant, announced recently, was the outgrowth of a proposal by H. J. Heinz II, chairman of the board of the H. J. Heinz Company of Pittsburgh. In a speech last September before the Fifth International Congress on Nutrition in Washington, Mr. Heinz suggested that the food industry establish and underwrite fellowships to bring students from all over the world to this country to train them in the nutritional sciences, food technology, and related fields. Several other major companies have responded with group fellowships. The fellowships, valued at $6,000, pay

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not only for tuition but also for transportation and living expenses for one year.

Companies agreeing to co-sponsor and underwrite the program are:

The Borden Company	3 fellowships
Campbell Soup Company	1 fellowship
Corn Products Company	3 fellowships
General Foods Corporation	1 fellowship
General Mills, Inc.	1 fellowship
H. J. Heinz Company	3 fellowships
The Pillsbury Company	1 fellowship

Each of the fellowships will be identified by the name of the sponsoring company.

The program is designed to give advanced students an understanding of food supplies, food technology, human nutritional requirements, the nature of deficiency diseases, nutrition in preventive medicine, and the problems involved in changing the food habits of large groups of people.

The graduates, according to Dr. Sebrell, will be competent to (a) identify the nature of critical nutrition deficiencies; (b) with knowledge of indigenous agricultural resources, to determine dietary adjustments, and (c) with public health training and nutrition education, to initiate action within their own geographic area. Dr. Sebrell pointed out that public health nutrition combines five sciences: Agriculture, Food Technology, Biostatistics, Public Health, and Nutrition.

"A unique and significant feature of our work in the Institute of Nutrition Sciences is our concept of teaching these subject matters in an interrelated program that crosses disciplinary lines," said Dr. Sebrell.

The course of study covers one academic year, beginning in September. Although preference is given to physicians, the minimum requirements for admission are a B.S. degree, with an interest in public health.

Twenety-one students are enrolled and at work in the Institute of Nutrition Sciences.

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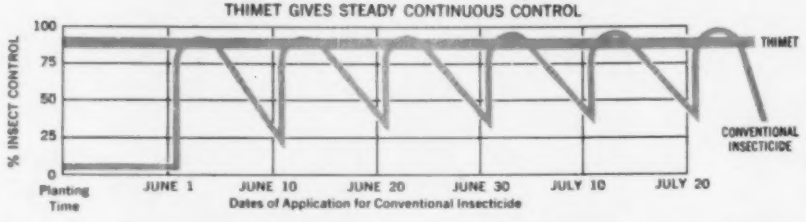

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How to use Thimet...what it does

Thimet Insecticide comes in granular form. You apply it in bands along the row, or in the furrow at planting time. As your potatoes start to grow, their roots pick up Thimet. It travels all through the plants, makes every stem and leaf deadly to insects.

In most cases, Thimet gives steady, high-level control through the season. In some areas where heavy, late-season build-ups of insects occur, *supplementary* use of a conventional insecticide may be necessary. In many major potato areas, Thimet gives season-long control of aphids, leafhoppers, leafminers, and psyllids and reduces flea beetle infestations. Thimet is easily applied by a granular applicator that attaches to the planting rig. This unit will accurately apply the material at planting time.

Write for leaflet PE 5095. American Cyanamid Company, Agricultural Division, New York 20, N. Y. ®*THIMET is American Cyanamid Company's trademark for phorate.*

The label instructions on Cyanamid products, and on products containing Cyanamid ingredients, are the result of years of research and have been accepted by Federal and/or State Governments. Always read the labels and carefully follow directions for use.

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